VEGETATION OF THE CATTERMOLE CREEK MARSH, A PLANNED STORMWATER IMPOUNDMENT BASIN, SQUAMISH ESTUARY, SEPTEMBER 1984

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Environment CANADA Environnement
2046080G VOL ISS 3 1986
CIR # 001

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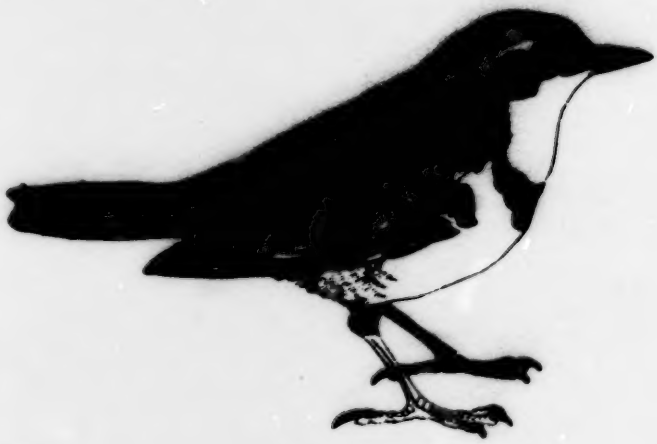

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Technical Report Series No. 3
Pacific and Yukon Region 1986
Canadian Wildlife Service

This series may be cited as:

Dawe, N.K., D.E.C. Trethewey, and A.C. Duncan. 1986. Vegetation of the Cattermole Creek marsh, a planned stormwater impoundment basin, Squamish estuary, September 1984. Technical Report Series No. 3. Canadian Wildlife Service, Pacific & Yukon Region, B.C.

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ISSUED UNDER THE AUTHORITY OF THE
MINISTER OF ENVIRONMENT
CANADIAN WILDLIFE SERVICE

Minister of Supply and Services Canada 1986
Catalogue No. CW69-5/3E
ISBN 0-662-14803-7
ISSN 0831-6481

Copies may be obtained from:

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Pacific and Yukon Region
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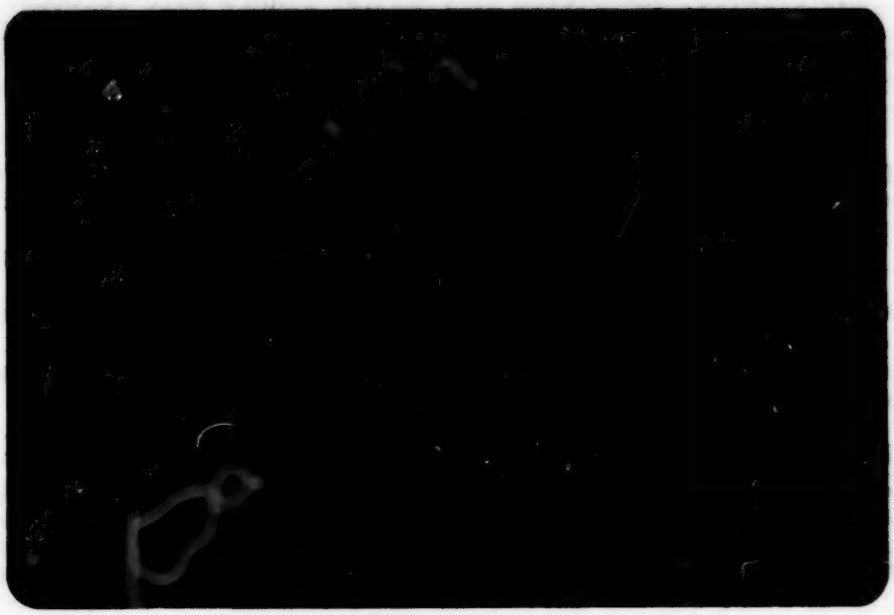

Cattermole Creek marsh, 14 August, 1984.
Photo by Sean Boyd, C.W.S.

ABSTRACT

To determine the effect of impounding stormwater within an area of the Cattermole Creek intertidal marsh, Squamish River estuary, baseline vegetation data were gathered from the marsh in September 1984.

Three permanent transects were established across the marsh and from a total of 100 releves, 26 species of vascular plants were recorded. Carex lyngbyei, Potentilla pacifica, Triglochin maritimum, and Deschampsia cespitosa dominated the vegetation. Four intertidal plant communities were identified within the study area and are described along with elevation and soilwater salinity data.

Requirements for a five year monitoring program of the marsh are also discussed.

RESUME

Afin de déterminer l'effet de l'endiguement des eaux d'évacuation (à ciel ouvert) dans un certain secteur du marais intertidal, de Cattermole Creek, dans l'estuaire de la rivière Squamish, on a relevé des donnees sur la végétation du marais, en septembre 1984.

On établi trois transects permanents dans le marais. Sur le total de 100 relevés, on a enregistré 26 especes de plantes vasculaires. Les plantes dominantes étaient: Carex lyngbyei, Potentilla pacifica, Triglochin maritimum et Deschampsia cespitosa. On a identifié quatre groupes de plantes intertidales a l'intérieur du secteur étudié. L'étude comprend la description de ces plantes ainsi que des données sur la profondeur et la salinité de l'eau absorbée par le sol.

La rapport examine aussi les besoins justifiant un programme d'étude de 5 ans portant sur le marais.

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ACKNOWLEDGEMENTS

Field assistance was provided by Bruce Cox and Jacques Sirois. Elevation data were gathered by Gilbert Bradshaw with assistance from a Fisheries Resource Employment Development for Youth crew, Larry Delmistro, Job Coordinator. Kevin Conlin, Bob McIndoe, and the District of Squamish provided logistical support. F.E. Stephenson and T. Ma, Institute of Ocean Sciences, provided the tidal inundation data for Pt. Atkinson, and instructions which enabled a conversion to Cattermole Creek marsh elevations. John Smith commented on the statistical analysis. Sean Boyd and Laszlo Retfalvi reviewed the manuscript. Susan Garnham typed the manuscript.

INTRODUCTION

The community of Squamish is located near the Squamish River estuary at the head of Howe Sound (Figure 1). The downtown core, located on the low-lying estuarine floodplain of the river, has required flood protection by dykes and drainage works. Despite those measures, frequent heavy rains in the area have often combined with high tides to cause flooding.

To help relieve that problem, the District of Squamish began planning in early 1982 for the creation of a controllable stormwater impoundment area. The area would be used to store excess runoff during periods of heavy rain where high tidal conditions would otherwise preclude gravity run-off from within the dyke. The site selected was an area of intertidal marsh in the Cattermole Creek basin (Figure 1).

PROJECT DESCRIPTION

The proposal involved the installation of a flood gate on upper Cattermole Creek at a point immediately upstream of the Third Avenue Bridge over the creek (Figure 2). The floodgate would only be closed when the threat of flooding was imminent. Otherwise, it would remain open and normal tidal flushing of the basin would occur. The floodgate would have flap valves to allow drainage of the basin, but would prevent water from passing upstream into the impoundment area on a rising tide. Closure of the gate would prevent tidal inundation of the upstream area, leaving it available for use as a stormwater impoundment area. The flap valves would open on a falling tide to allow the stormwater to drain, after which the above-described cycle could repeat. Construction of the system took place in the fall of 1984, and it is now in use (Appendix 8).

NEED FOR THE PRESENT STUDY

Upon review of the above-described proposal by resource agencies (Environment Canada, Dept. of Fisheries and Oceans, B.C. Ministry of Environment), it was agreed that a change in the character of the intertidal marsh in the impoundment area could occur.

A number of operational constraints were discussed between the resource agencies and the District of Squamish. The need to monitor effects on the marsh was identified. Unfortunately, the District did not budget for the necessary pre-construction monitoring. Instead, it proceeded with final design and tendering for the work in the summer of 1984.

Negotiation with the District resulted in an agreement that the resource agencies would conduct the pre-construction monitoring in 1984, with the District assuming responsibility for post-construction monitoring in 1985 and future years. That monitoring would continue for as long as necessary (to a maximum of five years) to demonstrate water impoundment effects on the marsh, adverse or otherwise. This report presents the results of the 1984 pre-construction monitoring.

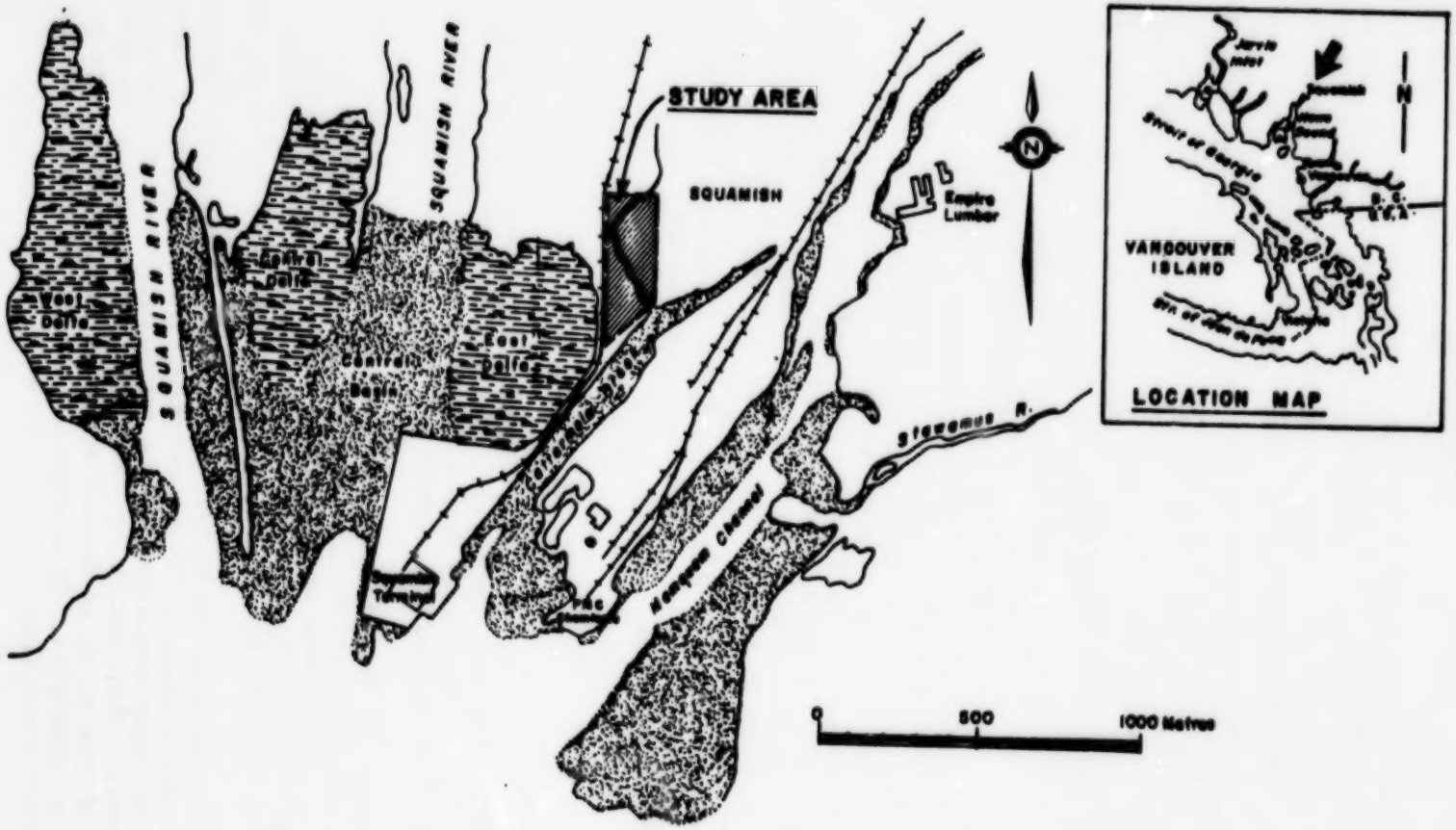

Figure 1. Location of the Cattermole Creek study area at the Squamish River estuary.

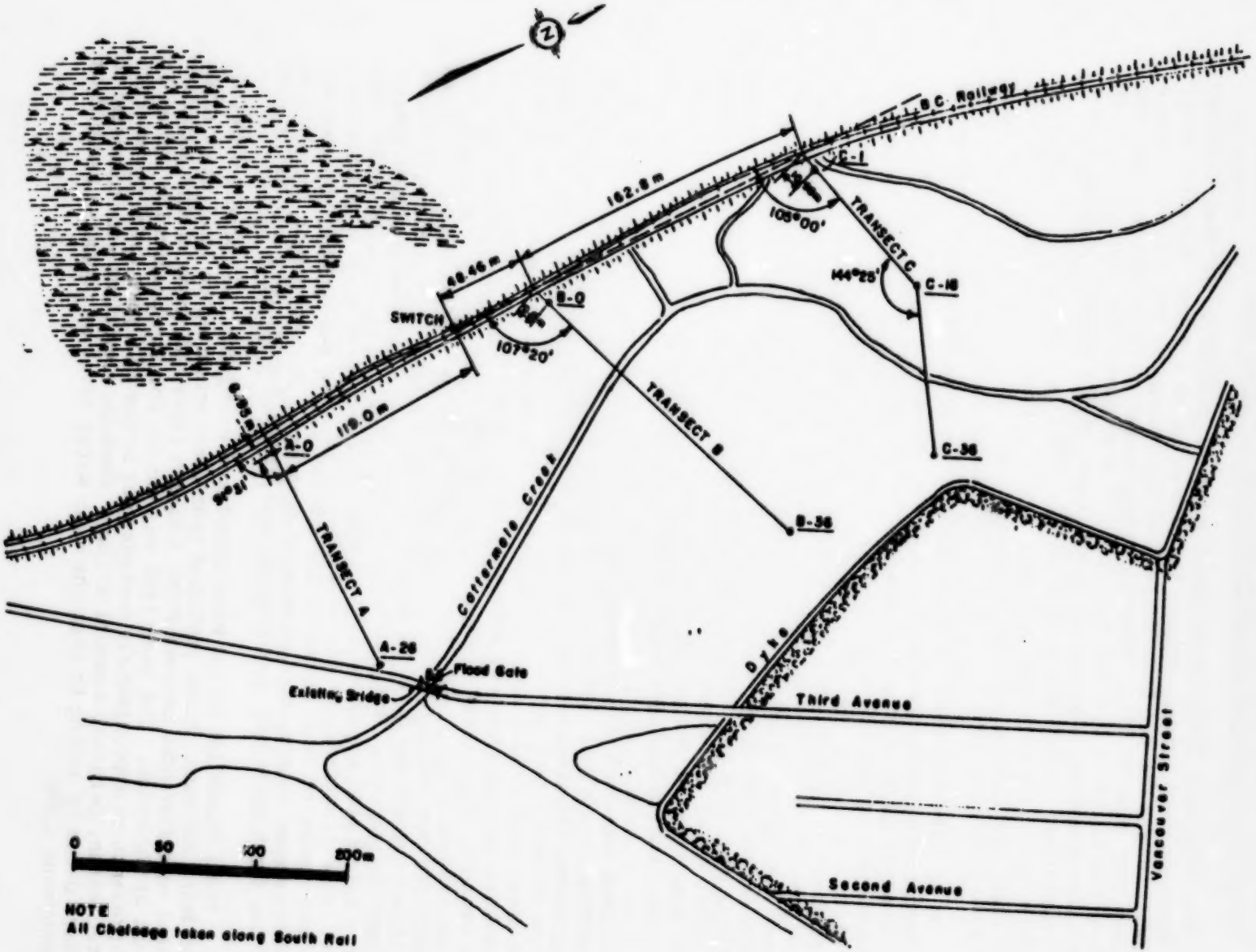

Figure 2. District of Squamish flood control basin. Locations of vegetation survey transects, 25 September 1984.

LOCATION AND DESCRIPTION OF THE STUDY AREA

The Cattermole Creek marsh (about 8 ha) is located on the east delta of the Squamish River estuary (Figure 1). The creek is a former dendritic tidal channel that was cut off from the rest of the estuary by the British Columbia Railway rail line in 1972. However, tidal inundation still occurs. The east side of the marsh is bounded by a dyke which protects the Town of Squamish from tidal flooding. Qualitative descriptions of the estuary in general have been summarized by the Habitat Work Group (1981).

METHODS

On 25 September 1984, three vegetation transects were established across the Cattermole Creek marsh to cover the low, intermediate and high elevations of the marsh platform (Figure 2 and Appendix 8). Wooden stakes were driven at 5 m intervals along the transects to denote the center of each releve (or vegetation sample). All vascular plant species within a 1 m^2 releve were identified and recorded (see Dawe and White, 1982). Nomenclature follows that of Hitchcock and Cronquist (1973). Because the study was conducted well beyond the normal growth and flowering period of many of the plants, some species were difficult to identify and have only been taken to genera or family. The relative cover of each species was determined using the Braun-Blanquet cover abundance scale (Appendix 1). Substrate elevation data were also taken at the center of each releve. Care was taken to ensure that survey-related disturbance to the vegetation communities was minimized.

Data were analysed using the reciprocal averaging multivariate technique described by Orloci (1978). That method has a dual purpose: a single application results in the ordination of both samples (releves) and species in terms of best fit of one to the other. Species with similar site distribution and sites with similar species composition are related independant of species abundance or site richness (Pimintel 1979). Analysis was carried out using the computer program RQT (Orloci 1978) on an Apple II+ microcomputer. Species with frequencies <= 5% were excluded from analysis. Frequency of occurrence was calculated by summing the number of occurrences of a species within a dataset and dividing that by the total number of possible occurrences within the dataset. Best estimates of mean cover/abundance for each species were calculated by summing the midpoint of each Braun-Blanquet scale range (ie. by setting r=.01, +=.05, 1=3, 2=15, 3=37.5, 4=67.5, 5=87.5) and dividing by the number of occurrences of the species within the dataset. Species and releve scores were plotted on scatter diagrams. Product moment correlations of the first three releve ordination axes with elevation data were calculated.

Tidal inundation ratios were calculated using the 1983 predicted tides for Point Atkinson. Those predicted tides were converted to local chart datum based on differences between Point Atkinson tides and those of the secondary port at Squamish. The year 1983 was chosen for the prediction set as it represents an approximately average year in the 18.6 year tidal cycle (Fred Stephenson, personal communication). Geodetic elevations were converted to chart datum by adding to them the mean water level at Squamish taken from Anonymous (1984).

Samples of soil water salinity were taken by squeezing a drop of water from a small soil sample onto an American Optical hand refractometer and reading the value directly.

RESULTS

From 100 releves a total of 26 species of vascular plants was recorded (Appendix 2). Of those species, four dominated the flora, occurring with frequencies of 20% or more. Carex lyngbyei occurred with the highest frequency and mean cover overall, followed by Potentilla pacifica, Triglochin maritimum, and Deschampsia cespitosa (Table 1). Cover/abundance data for species within transects is given in Appendices 3 and 4.

Canonical correlations for the first three sets of species scores and releve scores are high (Appendix 5) suggesting that the reliability of the species scores as ordering criteria is high (Orloci 1978). Seventy-five percent of the total chi square was accounted for by the first three canonical variates. Species scores were plotted on a three-dimensional scatter diagram to show their relationships with one another (Figure 3). Four species clusters are apparent (A-D), and allow the interpretation of the three-dimensional scatter diagram of the releve scores (Figure 4). For example, group AJ in Figure 4 is dominated by those species in cluster A of Figure 3.

Figure 4 suggests four major clusters (AJ, CP, C, R) which we have considered as vegetation communities. Table 2 shows the communities and their component species. Product moment correlation of releve elevations with axis I releve scores gives a correlation coefficient of $r=-0.69$ ($p<0.001$), which suggests that the communities are good indicators of elevation. Axis I, Figure 4, could also then be interpreted as decreasing in elevation from 0 to 1.

Elevation data are shown in Appendix 7 and have been summarized in Figure 5 and Table 3. Table 3 gives ranges and mean elevations of vegetation communities for each transect and for all data combined. Mean inundating water ratios per 24h day and daylight hours for each community are also shown. Because Carex lyngbyei grows well at lower elevations on channel edges, we have separated those elevations from the major Carex-flats community. Ruppia maritima too, can grow at a broad range of elevations where standing water occurs, therefore Ruppia has been excluded from the Table.

Salinity of the soil water ranged from 0°/oo to 11°/oo. Water salinity of Cattermole Creek was 5°/oo at transect C and 8°/oo near the end of transect A.

Table 1. Vascular plant species mean cover-abundance (%) and frequency of occurrence (%) of the Cattermole Creek Marsh. Values are rounded to nearest integer. See Appendix 2 for key to species names.

Data for releve 1 to releve 100

	Species	Mean cover/abun	Frequency
1	CARX LYNG	54	87
2	POTE PACI	12	35
3	TRIG MARI	4	33
4	DESC CESP	17	20
5	JUNC BALT	5	15
6	RUPP MARI	17	14
7	AGRO ALBA	36	12
8	SONC ARVE	1	9
9	DAUC SP ?	8	8
10	HORD BRAC	5	8
11	ASTR SPEC	4	8
12	LEGU SPEC	1	8
13	UMBL SPEC	1	7
14	LILA OCCI	1	8
15	RANU CYMB	*	8
16	PLAN MARI	8	5
17	ACHI MILL	7	5
18	PLAN MACR	2	5
19	SIDA HEND	1	5
20	ELEO PALU	2	4
21	STEL HEMI	*	4
22	OENA SP ?	2	3
23	MIAN DILA	1	3
24	SIUM SUAV	*	3
25	FRIT CAMS	1	1
26	TRIF WORM	1	1

Total number of releves = 100

* = Present, but less than 0.5%.

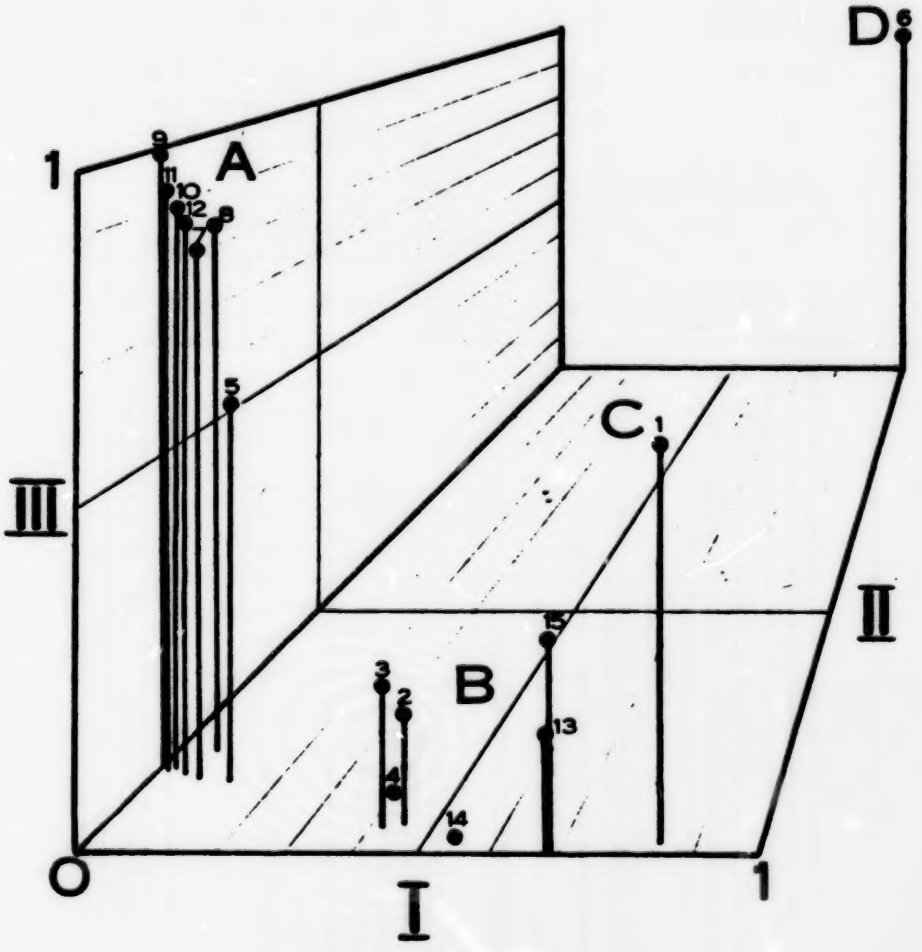

Figure 3. Three-dimensional scatter diagram of species scores for the first three canonical variates, Cattermole Creek marsh. Numbers refer to species in Table 1.

Key to cluster structure of Figure 4.

Symbol	Community	Transect( ) and Releves	N
R	Ruppia	(C) 4, 5, 29	3
C	Carex	(A) 3, 7-10, 13-18, 21-26 (B) 7-9, 12-16, 18, 19, 26-35 (C) 22-28, 31, 32	46
CP	Carex/Potentilla	(A) 1 (B) 1-6, 21-25 (C) 1, 2, 6, 15-21, 33-36	25
AJ	Agrostis/Juncus	(C) 7-14	8

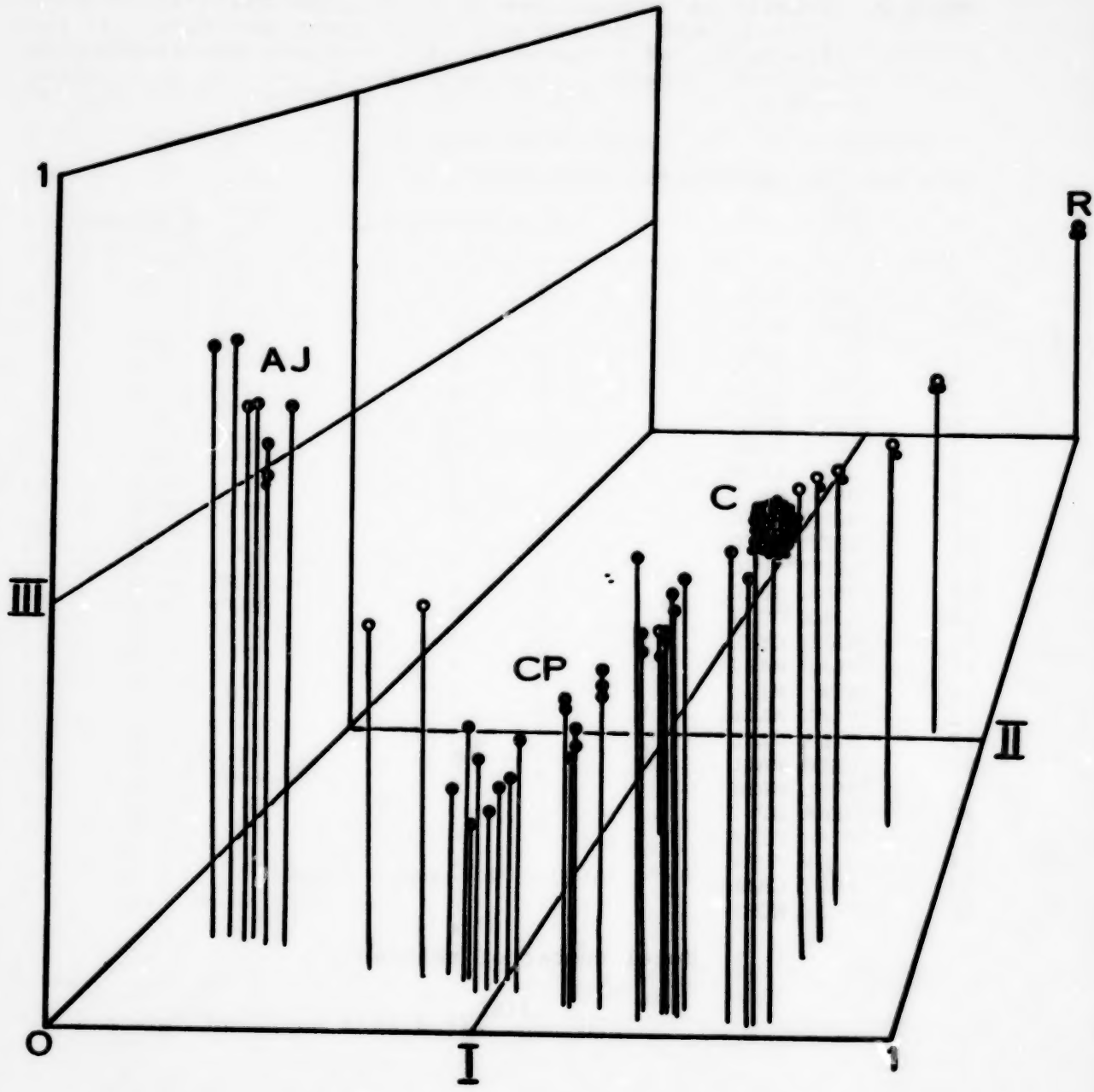

Figure 4. Three-dimensional scatter diagram of releve scores for the first three canonical variates, Cattermole Creek marsh. ◑(AJ) = Agrostis-Juncus, 1.301m to 1.631m; ●(CP) = Carex-Potentilla, 0.824m to 1.305m; ◑(C) = Carex, -0.656m to 0.792m; ◒(R) = Ruppia; ○ = transitional releves. Elevations are geodetic. See also Table 3.

Table 2. Vegetation communities of Cattermole Creek marsh with constituent species and their cover abundance (%) and frequency of occurrence (%). Values are rounded to nearest integer. See Appendix 2 for key to species names.

Data for Ruppia-aquatic community

	Species	Mean cover/abun	Frequency
1	CARX LYNG	0	0
2	POTE PACI	0	0
3	TRIG MARI	0	0
4	DESC CESP	0	0
5	JUNC BALT	0	0
6	RUPP MARI	47	100
7	AGRO ALBA	0	0
8	SONC ARVE	0	0
9	DAUC SP ?	0	0
10	HORD BRAC	0	0
11	ASTR SPEC	0	0
12	LEGU SPEC	0	0
13	UMBL SPEC	0	0
14	LILA OCCI	0	0
15	RANU CYMB	0	0
16	PLAN MARI	0	0
17	ACHI MILL	0	0
18	PLAN MACR	0	0
19	SIDA HEND	0	0
20	ELEO PALU	0	0
21	STEL HEMI	0	0
22	OENA SP ?	0	0
23	MIAN DILA	0	0
24	SIUM SUAV	0	0
25	FRIT CAMS	0	0
26	TRIF WORM	0	0

Total number of releves = 3

Table 2. (continued)

Data for Carex community

	Species	Mean cover/abun	Frequency
1	CARX LYNG	75	100
2	POTE PACI	0	0
3	TRIG MARI	0	0
4	DESC CESP	0	0
5	JUNC BALT	0	0
6	RUPP MARI	0	0
7	AGRO ALBA	0	0
8	SONC ARVE	0	0
9	DAUC SP ?	0	0
10	HORD BRAC	0	0
11	ASTR SPEC	0	0
12	LEGU SPEC	0	0
13	UMBL SPEC	3	2
14	LILA OCCI	0	0
15	RANU CYMB	1	4
16	PLAN MARI	0	0
17	ACHI MILL	0	0
18	PLAN MACR	0	0
19	SIDA HEND	0	0
20	ELEO PALU	1	2
21	STEL HEMI	0	0
22	OENA SP ?	0	0
23	MIAN DILA	0	0
24	SIUM SUAV	*	4
25	FRIT CAMS	0	0
26	TRIF WORM	0	0

Total number of releves = 46

3(b)

* = Present, but less than 0.5%.

Table 2. (continued)

Data for Carex/Potentilla community

	Species	Mean cover/abun	Frequency
1	CARX LYNG	32	100
2	POTE PACI	15	96
3	TRIG MARI	3	96
4	DESC CESP	17	60
5	JUNC BALT	1	32
6	RUPP MARI	0	0
7	AGRO ALBA	20	16
8	SONC ARVE	0	0
9	DAUC SP ?	0	0
10	HORD BRAC	0	0
11	ASTR SPEC	0	0
12	LEGU SPEC	1	4
13	UMBL SPEC	1	24
14	LILA OCCI	1	32
15	RANU CYMB	*	16
16	PLAN MARI	1	16
17	ACHI MILL	0	0
18	PLAN MACR	1	12
19	SIDA HEND	*	8
20	ELEO PALU	3	8
21	STEL HEMI	*	16
22	OENA SP ?	0	0
23	MIAN DILA	0	0
24	SIUM SUAV	*	4
25	FRIT CAMS	0	0
26	TRIF WORM	0	0

Total number of releves = 25

3(c)

* = Present, but less than 0.5%.

Table 2. (continued)

Data for Agrostis/Juncus community

	Species	Mean cover/abun	Frequency
1	CARX LYNG	3	12
2	POTE PACI	7	100
3	TRIG MARI	5	87
4	DESC CESP	9	50
5	JUNC BALT	10	87
6	RUPP MARI	0	0
7	AGRO ALBA	45	100
8	SONC ARVE	1	100
9	DAUC SP ?	8	100
10	HORD BRAC	5	100
11	ASTR SPEC	4	100
12	LEGU SPEC	1	87
13	UMBL SPEC	0	0
14	LILA OCCI	0	0
15	RANU CYMB	*	12
16	PLAN MARI	0	0
17	ACHI MILL	7	62
18	PLAN MACR	2	25
19	SIDA HEND	2	50
20	ELEO PALU	0	0
21	STEL HEMI	0	0
22	OENA SP ?	2	37
23	MIAN DILA	1	37
24	SIUM SUAV	0	0
25	PRIT CAMS	1	12
26	TRIF WORM	1	12

Total number of releves = 8

3(d)

* = Present, but less than 0.5%.

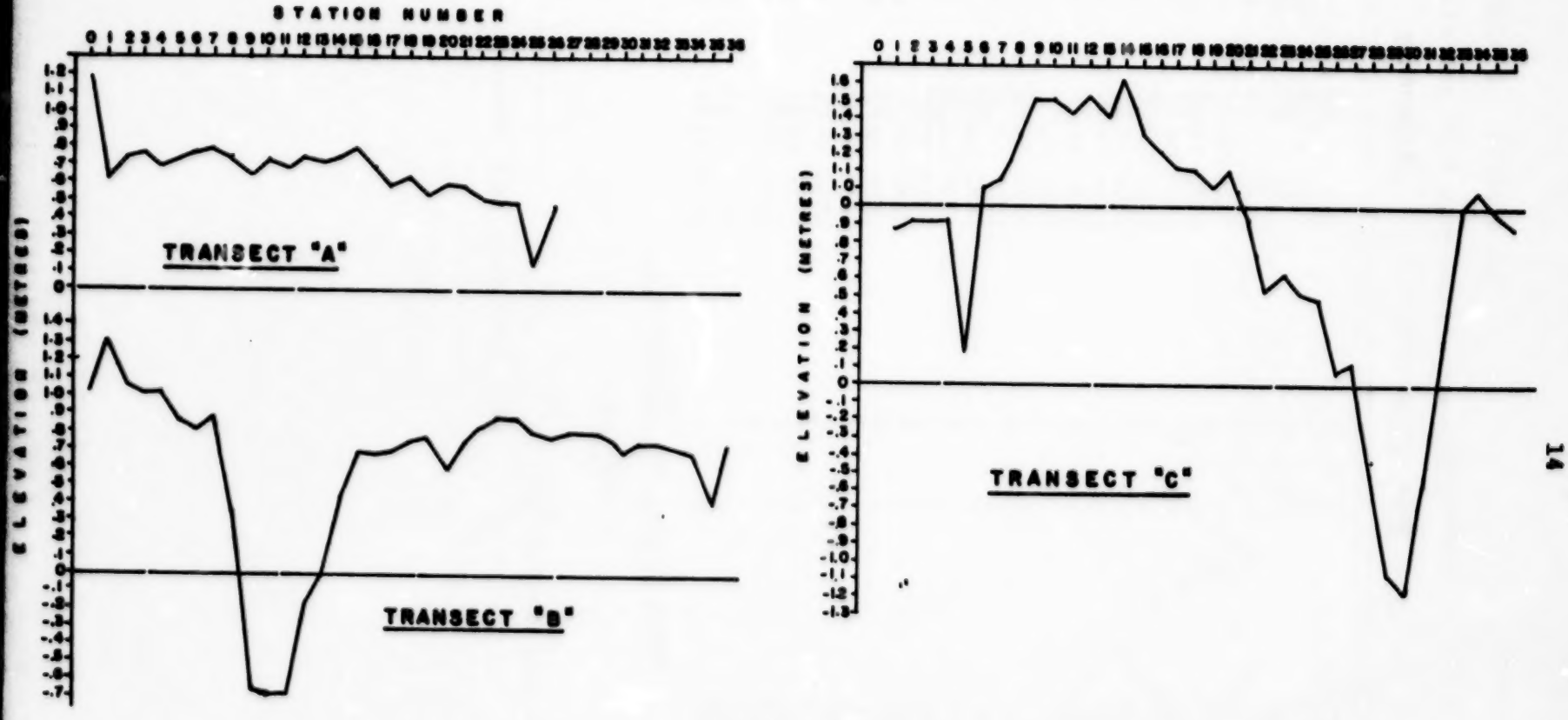

Figure 5. Transect profiles (m geodetic) of vegetation transects, Cattermole Creek marsh, 25 September 1984.

Table 3. Geodetic and Chart Datum elevations with related inundation periods for selected vegetation communities of Cattermole Creek marsh, Squamish River estuary. (Sample sizes are in parentheses; R()=Range).

Community	Mean elevations (in meters)		Mean Annual Inundation (%)	
	Geodetic	Above Chart datum	Full day	Daylight hours only
Transect A				
CARX-Channel (2) R(-.487 to -.140)	-.314	2.83	65.2	36.3
CARX-Flats (15) R(.47 to .76)	0.646	3.79	29.0	15.9
CARX/POTE (1)	1.198	4.33	8.2	3.9
Transect A				
CARX-Channel (5) R(-.656 to .365)	-.012	3.13	56.6	31.5
CARX-Flats (15) R(.393 to .792)	0.715	3.85	26.6	14.5
CARX/POTE (11) R(.824 to 1.304)	0.925	4.06	17.8	9.7
Transect C				
CARX-Channel (5) R(-.552 to .189)	-.122	3.02	60.5	33.8
CARX-Flats (4) R(.481 to .634)	0.540	3.68	33.3	18.8
CARX/POTE (14) R(.867 to 1.305)	1.042	4.18	12.5	6.9
AGRO/JUNC (8) R(1.301 to 1.631)	1.484	4.62	1.3	0.8
Grand Mean				
CARX-Channel (12) R(-.656 to .365)	-.108	3.03	60.0	33.5
CARX-Flats (34) R(.393 to .792)	0.664	3.80	27.3	15.4
CARX/POTE (25) R(.824 to 1.305)	0.998	4.14	14.2	7.9
ARGO/JUNC (8) R(1.301 to 1.631)	1.484	4.62	1.3	0.8

DISCUSSION

Since the purpose of this study was to provide baseline data to measure changes in the vegetation of the Cattermole Creek marsh, little discussion is necessary. We would, however, like to make two points.

Firstly, vegetation of the Cattermole Creek marsh is similar to that of other brackish marshes in the Pacific Northwest (Dawe and White 1982, Eilers 1975). However, the Cattermole Creek marsh differs somewhat in that its pure stands of Carex are extensive and are not just restricted to edges of tidal channels. Carex lyngbyei is one of the most important vegetative components of our coastal marshes. It grows best under brackish conditions such as those found on the Cattermole Creek marsh, but can also grow under relatively fresh or saline conditions. Under the two latter conditions, however, its productivity seems to decrease (Dawe and White, in press). It is the most productive of our estuarine vascular plants with above-ground biomass estimates at Squamish of 1322 g dry wt/m^2 (Levings and Moody 1976). Carex also produces large numbers of seeds which form an important part of the diet of many estuarine animals, notably waterfowl and songbirds. Perhaps the most important feature of Carex, aside from its high productivity, is its characteristic of breaking down rapidly. Eilers (1975) found that Carex litter in May could be exhausted in as little as six days, while a community of Juncus or Agrostis could take over 300 days. Once broken down into tiny particles, Carex becomes available to the scores of detritivores such as amphipods, isopods, and clams that serve as food to higher vertebrates such as birds and fish. Based on Levings and Moody's (1976) data we estimated that Cattermole Creek marsh produces about 75 tonnes of Carex lyngbyei dry weight per year. Loss of that detrital input could have a negative impact on the overall productivity of the estuary.

Secondly, the location of communities within the estuarine marsh seems to be governed mainly by the elevation of the marsh platform which, in turn, determines the degree of inundation and exposure that the marsh plants must undergo (Dawe and White 1982). In the case of Cattermole marsh, changes in inundation periods could cause a change in the vegetation composition of a community which, in turn, could affect the overall productivity of the estuary.

To determine changes such as those discussed above, the following activities are required.

1) The vegetation survey should be repeated annually, about the first two weeks in July, for at least the next five years (1985-1989). Soil water salinity measurements at each releve should also be gathered during the vegetation survey.

2) Surface and bottom measurements of the salinity of the inundating water should be obtained from at least three sites (ends and channels) along each transect during a high tide, preferably four times througout the spring and summer (March, May, July and September).

3) Above-ground biomass estimates should be obtained each year, about the first two weeks in July, to compare the Carex productivity of the Cattermole marsh with that of a similar, adjacent "natural" marsh. That could most easily be accomplished by surveying a linear control transect on the west side of the B.C. Rail embankment and staking 36 releve locations at 5m intervals along the transect. The geodetic elevation of each releve centre should be determined. Within each $1m^2$ releve on the control transect and on Transect B, within the Cattermole basin, record the releve number and measure the above-ground length of the tallest Carex plant to the nearest 0.5cm. The plant should be measured from the ground, adjacent to the plant stem, to the end of the longest leaf, including the brownish tip.

4) A water guage should be installed inside the Cattermole Creek basin to record automatically the tidal elevations and durations, so that differences in inundation periods from the norm can be calculated.

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APPENDIX 1

Braun-Blanquet cover-abundance scale
(from Mueller-Dombois and Ellenberg 1974)

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5 - any number, with cover > 75%

4 - any number, with cover of 51% - 75%

3 - any number, with cover of 26% - 50%

2 - any number, with cover of 6% - 25%

1 - numerous, with cover of 1% - 5%

+ - few, with small cover (<1%)

R - solitary, with small cover

APPENDIX 2

Vascular plant species list compiled from all releves within the Cattermole Creek marsh, Squamish River estuary, September 1984.

	Acronym	Species
1	CARX LYNG	Carex lyngbyei Hornem.
2	POTE PACI	Potentilla pacifica Howell
3	TRIG MARI	Triglochin maritimum L.
4	DESC CESP	Deschampsia cespitosa (L.) Beauv.
5	JUNC BALT	Juncus balticus Willd.
6	RUPP MARI	Ruppia maritima L.
7	AGRO ALBA	Agrostis alba L.
8	SONC ARVE	Sonchus arvensis L.
9	DAUC SP ?	Daucus species?
10	HORD BRAC	Hordeum brachyantherum Neusk.
11	ASTR SPEC	Aster species
12	LEGU SPEC	Leguminosae species
13	UMBL SPEC	Umbelliferae species
14	LILA OCCI	Lilaeopsis occidentalis Coult. & Rose.
15	RANU CYMB	Ranunculus cymbalaria Pursh
16	PLAN MARI	Plantago maritima L.
17	ACHI MILL	Achillea millefolium L.
18	PLAN MACR	Plantago macrocarpa Cham & Schlecht
19	SIDA HEND	Sidalcea hendersonii Wats.
20	ELEO PALU	Eleocharis palustris (L.) R. & S.
21	STEL HEMI	Stellaria hemifusa Rottb.
22	OENA SP ?	Oenanthe species?
23	MIAN DILA	Mianthemum dilatatum (Wood) Nels. & Macbr.
24	SIUM SUAV	Sium sauve Walt.
25	FRIT CAMS	Fritillaria camschatcensis (L.) Ker-Gawl
26	TRIF WORM	Trifolium wormskjoldii Lehm.

APPENDIX 3

Vegetation data gathered at the Cattermole Creek marsh, September 1984. See Appendix 2 for key to species.

CATTERMOLE CREEK BASIN - VEGETATION TRANSECT A

RELEVE NUMBER

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
CARX LTNG		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
POTE PACI		+																									
TRIG MARI																											
DESC CESP		4																									
JUNC BALT																											
RUPP MARI		2	2		2	2	+	+				+	+							2	+						
AGRO ALBA																											
SONC ARVE		+																									
DAUC SP ?																											
HORD BRAC																											
ASTR SPEC																											
LEGU SPEC																											
UMBL SPEC																											
LILA OCCI																											
RANU CYMB																											
PLAN MARI		3																									
ACHI MILL																											
PLAN MAJR																											
SIDA HERD																											
ELEO PALU																											
STEL MEDI																											
OENA SP ?																											
MIAM DILA																											
SIUM SUAV																											
FRIT CAMS																											
TRIF WORM																											

CATTERMOLE CREEK BASIN - VEGETATION TRANSECT B

RELEVE NUMBER

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
CARX LYNG	3	2	1	4	1	4	5	5	5	5			5	5	5	5	5	4	5	5	2	3	4	4	4	4	2	5	5	5	3	5	5	5	5	2	2
POTE PACI	R	2	1	2	3	1	2																+	1	2	2											
TRIG MARI		1	2	+	1	+	+											+				1	1	+	+												2
DESC CESP		2	1		2																																
JUNC BALT																																					
RUPP MARI																					2																
AGRO ALBA		+																																			
SONC ARVE																																					
DAUC SP ?																																					
HORD BRAC																																					
ASTR SPEC																																					
LEGU SPEC			+																																		
UMBL SPEC																							+		+			1									
LILA OCCI			+																					+													
RANU CYMB		+																											+	+							+
PLAN MARI		+	1																																		
ACHI MILL																																					
PLAN MACR			+																																		
SIDA HEND																																					
ELEO PALU			1																							1	+										+
STEL HEMI			+																																		
OENA SP ?																																					
MIAN DILA																																					
SIUM SUAV			R																										+	R						
FRIT CAMS																																					
TRIF WORM																																					

CATTERMOLE CREEK BASIN - VEGETATION TRANSECT C

RELEVE NUMBER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
CARX LYNG	3	2	3			2							1		2	3	+	2	3	1	1	5	5	5	5	5	5	5			5	5	3	2	2	3
POTE PACI	2	2	+			2	1	1	1	2	1	+	2	2	2	2	2	2	2	2	2												2	2	2	3
TRIG MARI	1	+				1	+	2	2	1	+	+		+	1	1	2	1	1	+	1												+	1	+	+
DESC CESP	1	+				3		2	2		1			1	1		1	+	1	3	3												2	3	3	
JUNC BALT	R					+	+	2	2	+	1	3	+		+				+	1	+													1	+	
RUPP MARI				5	2																								3							
AGRO ALBA						1	3	2	2	4	4	2	5	4	3		3																			
SONC ARVE							+	+	+	+	+	+	+	1																						
DAUC SP ?							2	+	2	+	1	2	1	2																						
HORD BRAC							1	2	2	+	1	+	+	1																						
ASTR SPEC							1	2	1	+	1	1	+	1																						
LEGU SPEC							+	1		+	+	1	+	+																						
UMBL SPEC		+																															+	+		+
LILA OCCI	+	+													+	+					+													+		
RANU CYMB							R								R			R	+																	
PLAN MARI																R	R																			
ACHI MILL							2	2	1	+		+																									
PLAN MACR							+						1				1			+																
SIDA HEND							1			+			+	1	R	+																				
ELEO PALU																																				
STEL HEMI																	R	R	+																	
OENA SP ?							1	+	1																											
MIAN DILA									+	+	+																									
SIUM SUAV																																				
FRIT CAMS									+																											
TRIF WORM									+																											

APPENDIX 4

Vascular plant species mean cover-abundance (%) and frequency of occurrence (%) by transect, for the Cattermole Creek marsh. Values are rounded to nearest integer. See Appendix 2 for key to species.

TRANSECT A

Data for releve 1 to releve 27

Species	Mean cover/abun	Frequency
CARX LYNG	52	100
POTE PACI	1	3
TRIG MARI	0	0
DESC CESP	62	3
JUNC BALT	0	0
RUPP MARI	8	37
AGRO ALBA	0	0
SONC ARVE	1	3
DAUC SP ?	0	0
HORD BRAC	0	0
ASTR SPEC	0	0
LEGU SPEC	0	0
UMBL SPEC	0	0
LILA OCCI	0	0
RANU CYMB	0	0
PLAN MARI	38	3
ACHI MILL	0	0
PLAN MACR	0	0
SIDA HEND	0	0
ELEO PALU	0	0
STEL HEMI	0	0
OENA SP ?	0	0
MIAN DILA	0	0
SIUM SAUV	0	0
FRIT CAMS	0	0
TRIF WORM	0	0

Total number of releves = 27

APPENDIX 4 continued

TRANSECT B

Data for releve 28 to releve 64

Species	Mean cover/abun	Frequency
CARX LYNG	63	94
POTE PACI	11	29
TRIG MARI	4	32
DESC CESP	11	8
JUNC BALT	0	0
RUPP MARI	15	2
AGRO ALBA	1	2
SONC ARVE	0	0
DAUC SP ?	0	0
HORD BRAC	0	0
ASTR SPEC	0	0
LEGU SPEC	1	2
UMBL SPEC	1	8
LILA OCCI	1	5
RANU CYMB	1	10
PLAN MARI	2	5
ACHI MILL	0	0
PLAN MACR	1	2
SIDA HEND	0	0
ELEO PALU	2	10
STEL HEMI	1	2
OENA SP ?	0	0
MIAN DILA	0	0
SIUM SAUV	*	8
FRIT CAMS	0	0
TRIF WORM	0	0

Total number of releves = 37

* = Present, but less than 0.5%.

APPENDIX 4 continued

TRANSECT C

Data for releve 65 to releve 100

Species	Mean cover/abun	Frequency
CARX LYNG	44	69
POTE PACI	13	63
TRIG MARI	4	58
DESC CESP	15	44
JUNC BALT	5	41
RUPP MARI	47	8
AGRO ALBA	40	30
SONC ARVE	1	22
DAUC SP ?	8	22
HORD BRAC	5	22
ASTR SPEC	4	22
LEGU SPEC	1	19
UMBL SPEC	1	11
LILA OCCI	1	16
RANU CYMB	*	11
PLAN MARI	*	16
ACHI MILL	7	13
PLAN MACR	2	11
SIDA HEND	1	16
ELEO PALU	0	0
STEL HEMI	*	8
OENA SP ?	2	8
MIAN DILA	1	8
SIUM SAUV	0	0
FRIT CAMS	1	2
TRIF WORM	1	2

Total number of releves = 36

* = Present, but less than 0.5%.

APPENDIX 5

Canonical correlations for the sets of species scores and releve scores of Cattermole Creek marsh.

CANONICAL CORRELATIONS

Set	1	R(X,Y) =	.878723061
Set	2	R(X,Y) =	.771170112
Set	3	R(X,Y) =	.598309413
Set	4	R(X,Y) =	.369614096
Set	5	R(X,Y) =	.31735513
Set	6	R(X,Y) =	.308061385
Set	7	R(X,Y) =	.26028611
Set	8	R(X,Y) =	.222365036
Set	9	R(X,Y) =	.203600837
Set	10	R(X,Y) =	.189821387
Set	11	R(X,Y) =	.152470969
Set	12	R(X,Y) =	.141945186
Set	13	R(X,Y) =	.0658646779
Set	14	R(X,Y) =	.0385669264

APPENDIX 6

Product moment correlations of releve elevations with axes I, II, and III releve scores.

Correlations:

N = 97

R(1,1) - .687046827
R(2,1) - .136495427
R(3,1) - .215057979

APPENDIX 7

Elevation data (m geodetic) of releve centres from Cattermole Creek marsh, 25 September 1984.

TRANSECT A		TRANSECT B		TRANSECT C	
STATION	STATION ELEVATION	STATION	STATION ELEVATION	STATION	STATION ELEVATION
A 0	1.193	B 0	1.074	C 1	0.867
A 1	0.625	B 1	1.304	C 2	0.911
A 2	0.748	B 2	1.070	C 3	0.900
A 3	0.750	B 3	1.039	C 4	0.900
A 4	0.677	B 4	1.009	C 5	0.196
A 5	0.707	B 5	0.864	C 6	1.054
A 6	0.760	B 6	0.826	C 7	1.532
A 7	0.763	B 7	0.868	C 8	1.301
A 8	0.741	B 8	0.339	C 9	1.516
A 9	0.640	B 9	-0.656	C 10	1.512
A 10	0.723	B 10	L-0.696	C 11	1.432
A 11	0.662	B 11	L-0.696	C 12	1.533
A 12	0.743	B 12	-0.183	C 13	1.417
A 13	0.728	B 13	0.077	C 14	1.631
A 14	0.747	B 14	0.365	C 15	1.305
A 15	0.676	B 15	0.682	C 16	1.218
A 16	0.663	B 16	0.679	C 17	1.157
A 17	0.562	B 17	0.686	C 18	1.116
A 18	0.643	B 18	0.744	C 19	1.089
A 19	0.527	B 19	0.774	C 20	1.107
A 20	0.583	B 20	0.571	C 21	0.944
A 21	0.559	B 21	0.722	C 22	0.528
A 22	0.513	B 22	0.824	C 23	0.634
A 23	0.472	B 23	0.872	C 24	0.515
A 24	0.513	B 24	0.854	C 25	0.481
A 25	-0.140	B 25	0.792	C 26	0.078
A 26	-0.487	B 26	0.764	C 27	0.110
		B 27	0.783	C 28	-0.435
		B 28	0.786	C 29	-1.261
		B 29	0.763	C 30	L-1.311
		B 30	0.668	C 31	-0.552
		B 31	0.724	C 32	0.189
		B 32	0.726	C 33	0.964
		B 33	0.704	C 34	1.026
		B 34	0.669	C 35	0.957
		B 35	0.393	C 36	0.874
		B 36	0.704		

L = Lower than

APPENDIX 8

Photographs of the Cattermole Creek Basin,
summer and fall 1984.

Photo Credits for Appendix 8

Sean Boyd, C.W.S.: No.'s 1 and 2.
Gilbert Bradshaw, E.P.S.: No's 3,4, and 5
Bruce Cox, M.O.E., F&W: No. 6.

Photograph No. 1. Upper Cattermole Creek, 14 August 1984. Looking south toward the Third Avenue bridge and the site of the proposed floodgate.

Photograph No. 2. Upper Cattermole Creek marsh, 14 August 1984. Looking north from the eastern approach to the Third Avenue Bridge.

Photograph No. 3. Approximate location of Transect "A" (dotted line), from A-0, 25 September 1984.

Photograph No. 4. Approximate location of Transect "B" (dotted line), from B-0, 25 September 1984.

Photograph No. 5. Approximate location of Transect C (dotted line), from C-1, 25 September, 1984.

Photograph No. 6. Downstream side of new floodgate on upper Cattermole Creek, mid-October, 1984. Approximate location of Transect "A" (dotted line) is shown in upper right-hand corner.